LATEST JET RESULTS FROM THE TEVATRON

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Recent QCD jet production measurements in $p\bar{p}$ collisions at $\sqrt{s} = 1.96\,\mathrm{TeV}$ at the Tevatron Collider at Fermilab are presented. Preliminary: inclusive jet, dijet, isolated photon + jet and Z + jets measurements are compared to available perturbative QCD models.

The production of particle jets with high transverse momenta in hadronic collisions is described in perturbative Quantum Chromodynamics (pQCD) as resulting from the hard scattering of strongly interacting constituents of the colliding hadrons.

Inclusive jet rates observed in hadronic collisions at high values of transverse momenta provide a basic test of pQCD. The DØ and CDF collaborations[1,2] have measured the inclusive jet production cross section using *midpoint cone* and k_T algorithms[3] using data corresponding to the integrated luminosities of about $1\,\mathrm{fb}^{-1}$. The DØ result[4] is shown in Figure 1 for two regions of rapidity[a] (closed and open circles). The error bars correspond to the total measurement uncertainty. The data are corrected for the jet energy scale (JES) determined from isolated photon plus jets events, selection efficiencies and migrations due to p_T resolution (an ansatz function convoluted with the jet p_T resolution measured directly in data). The JES is the dominant source of systematic uncertainty. The integrated luminosity is known with accuracy of 6%. The data are compared to the next-to-leading order (NLO) pQCD predictions computed using NLOJET++[5] with parton density functions (PDFs) from CTEQ6.1M,[6] after applying threshold corrections at 2-loop (next-to-next-leading-logarithm) accuracy.[7] The same jet algorithm was used in the calculations and the pQCD predictions are also corrected for hadronization effects using PYTHIA.[8] The theory describes the data well over the whole measured p_T range in all rapidity regions. The experimental uncertainties are competitive with those from the proton

[a] The rapidity y is defined as $y = -\frac{1}{2}\ln\frac{E+p_z}{E-p_z}$ where E and p_z denote the energy and the momentum component along the proton beam direction, respectively.

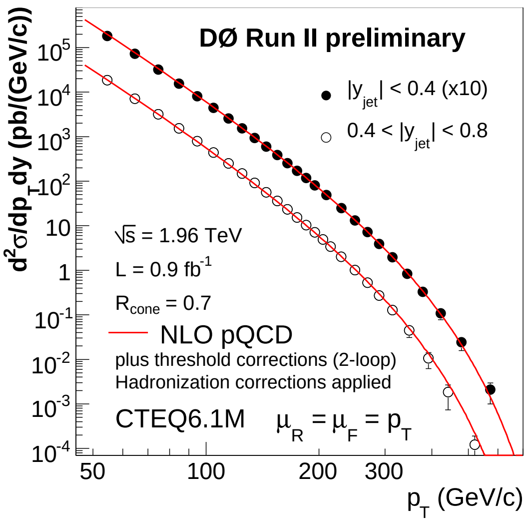

Figure 1: The inclusive jet differential cross section measured in two regions of jet rapidity.

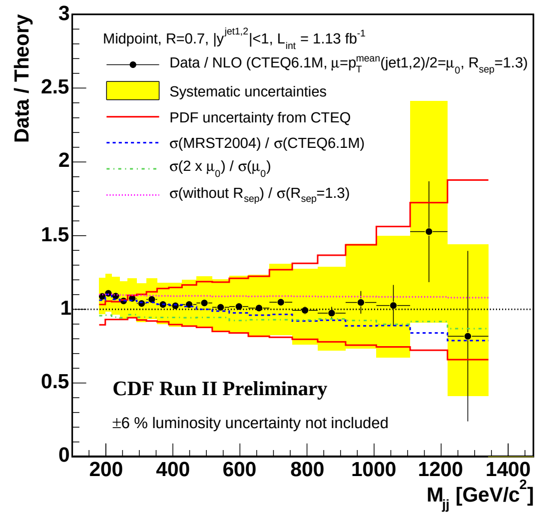

Figure 2: The data/theory ratio for dijet inclusive cross sections as a function of the dijet invariant mass.

PDFs and the data therefore further constrain the gluon density functions at high-x. Inclusive jet spectra measured by CDF are also in good agreement with the NLO pQCD predictions.[9]

The rate of dijet event produced in hadronic collisions not only provides a test of pQCD but also is sensitive to new physics such as compositeness and massive particles decays. The ratio of the dijet cross section measured by CDF to theory is shown as a function of dijet invariant mass (M_{jj}) in Figure 2. The measurement corresponds to $1.13\,\mathrm{fb}^{-1}$ and centrally produced jets. The jets were selected using midpoint cone algorithm.[3] The error bars and shaded bands represent the statistical and systematic uncertainties respectively. Theoretical predictions were calculated using NLOJET++[5] with PDFs from CTEQ6.1M[6] and corrected to the hadron level. The systematic errors are comparable to the PDF uncertainties and NLO pQCD predictions are consistent with the data over the whole measured M_{jj} range.

The production rates of $b\bar{b}$ jet pairs have also been studied by CDF using a data sample of $260\,\mathrm{pb}^{-1}$. Such a measurement provides insight into b-quark direct production, flavour excitation and gluon splitting mechanisms and also allows a test of radiative gluon corrections. The selected events were first required to contain two jets with transverse energy above 20 GeV associated to two displaced vertex tracks at the trigger level. A Run I cone algorithm[3] was used to identify the jets. Jets having a positively displaced secondary with respect to the jet axis were tagged as *"SVT b-jets"*. Two positively tagged jets with central pseudorapidities[b] and transverse energies of a leading and a second jet above 35 and 32 GeV respectively were required. The invariant mass of the tracks associated to the secondary vertex was fitted using signal and background Monte Carlo templates to determine the $b\bar{b}$ purity of the final event sample. The resulting purity was about 80%. The differential cross section measured as a function of the azimuthal angle between two jets ($\Delta\phi_{jj}$), unfolded to the hadron level, is shown in Figure 3 (full squares). The error bars and shaded bands correspond to the measured statistical and systematic uncertainties respectively. The data are compared to three theoretical models: two predictions at leading order (LO) from PYTHIA[8] (Tune A) and HERWIG[10] with PDFs from CTEQ5L[11] and a NLO prediction from MC@NLO[12] using CTEQ6.1M[6] PDFs and with multiple parton interactions simulated by JIMMY.[13] The $\Delta\phi_{jj}$ spectrum is sensitive to contributions arising from soft gluon radiation and therefore only the NLO pQCD model describes data reasonably well even at large departures from a back-to-back jet topology.

Photons produced directly in parton-parton QCD interactions arrive unaltered at the elec-

[b] Pseudorapidity η is defined as $\eta = -\ln\tan\frac{\theta}{2}$, where θ is the polar angle w.r.t. the proton beam direction.

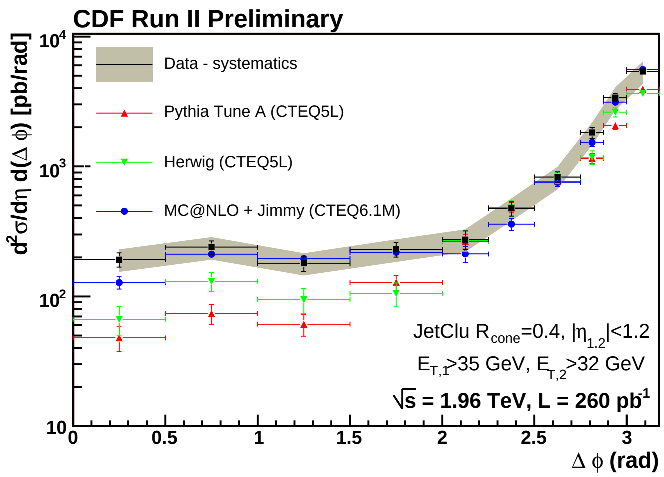

Figure 3: The differential $b\bar{b}$ cross section as a function of the azimuthal angle between two jets.

tromagnetic calorimeter and carry clean information of the dynamics of the hard scatter. At the Tevatron prompt photon production is dominated by the Compton scattering subprocess $qg \to \gamma q$ for photon transverse momenta $p_T^{\gamma} \lesssim 150\,\mathrm{GeV/c}$. The differential cross section $d^3\sigma/(dp_T^{\gamma}\, d\eta^{\gamma}\, d\eta^{jet})$ for the production of a photon and a jet measured by DØ using a $1.1\,\mathrm{fb}^{-1}$ data sample is shown in Figure 4.[14] The jets were reconstructed using a midpoint cone algorithm[3] and were required to have: transverse momenta $p_T^{jet} > 15\,\mathrm{GeV/c}$ and pseudorapidities either in the central calorimeter (*"CC"*, $|\eta^{jet}| < 0.8$) or in the end cap (forward) calorimeter region (*"EC"*, $1.5 < |\eta^{jet}| < 2.5$). Photons were selected with transverse momenta $30 < p_T^{\gamma} < 300\,\mathrm{GeV/c}$ and central pseudorapidities $|\eta^{\gamma}| < 1$. Strong isolation criteria were imposed on photon candidates in order to filter background events with neutral hadrons decaying to photons in the final state. The purity of the resulting sample was estimated with the help of an artificial neural network trained to distinguish between direct photons and background. The measured cross section is corrected for the finite resolution of the calorimeter. Events with a leading jet and a photon contained in the same hemisphere in terms of their pseudorapidities are denoted as *"SS"* (same sign) while the remaining ones as *"OS"* (opposite sign). The four curves overlaid on the data represent the NLO pQCD predictions from JETPHOX[15] with the choice of CTEQ6.1M[6] PDFs and fragmentation functions.[16] The theory qualitatively reproduces the data in some kinematic regions.

Jets accompanied by W or Z vector bosons in $p\bar{p}$ collisions constitute an important background for top quark production, Higgs and SUSY searches. Their production rates are also sensitive to physics beyond the Standard Model (compositeness and decays of heavy objects). In addition, Z+jets events are suitable for testing phenomenological models of the underlying event in $p\bar{p}$ collisions by studying integrated and differential jet shapes or energy flow with respect to the momentum of a Z boson. The CDF collaboration studied production of Z+jets events with Z bosons decaying into e^+e^- pair using $1.1\,\mathrm{fb}^{-1}$ of data. Such a channel provides much cleaner experimental signature than W+jets one, albeit has 10 times smaller cross section. The analysis covered the following kinematic region: jets reconstructed using midpoint cone algorithm[3] having $p_T^{jet} > 30\,\mathrm{GeV/c}$ and $|\eta^{jet}| < 2.1$, electrons with $E_T^{e\,1,2} > 25\,\mathrm{GeV}$, $|\eta^{e\,1}| < 1$, $|\eta^{e\,2}| < 2.8$ and isolated from jet cones. The acceptance window for the invariant mass of an e^+e^- pair was taken to be 66 to $116\,\mathrm{GeV/c^2}$ to suppress background. The cross section as a function of the transverse momentum of a leading jet is shown in Figure 5 (closed circles) and is compared to the NLO prediction using MCFM[17] with CTEQ6.1M[6] PDFs after corrections to the hadron level (open circles). The data/theory ratio is consistent with unity, although statistical errors dominate at $p_T^{jet} > 100\,\mathrm{GeV/c}$ region.

Present experimental data on QCD jets from the Tevatron Collider are reasonably well

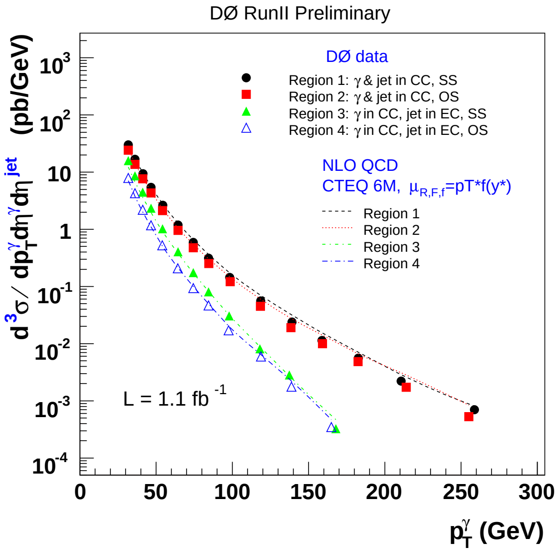

Figure 4: The differential γ+jet cross sections as a function of photon p_T for four rapidity regions.

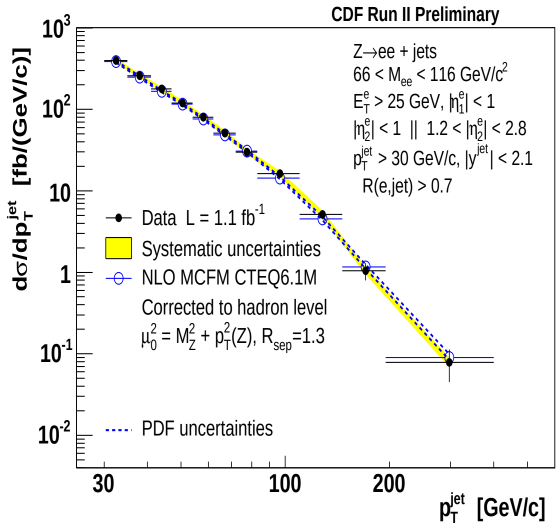

Figure 5: The differential $Z(\rightarrow e^+e^-)+$jets cross section as a function of jet p_T.

described by existing next-to-leading calculations after applying parton-to-hadron level corrections. The CDF and DØ collaborations have now collected about 2.2 fb^{-1} of data on tape and anticipate up to 8 fb^{-1} by end of 2009. This should make possible even higher precision tests of pQCD theory over extended kinematic regions.

Acknowledgments

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